US Army TACOM

Army Transformation Reliability Improvement Program

"Cultural Changes in Systems Engineering"

presented to:

Systems Engineering Conference

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TACOM – Mobility and Firepower for America's Army

Topics

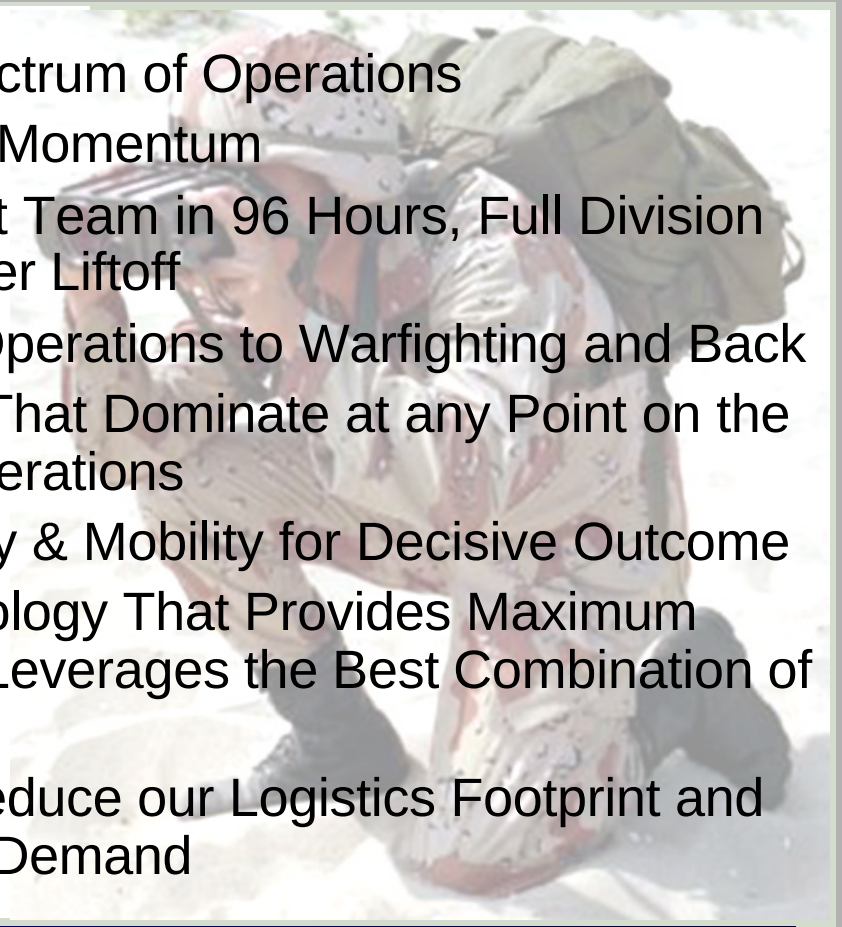
"Cultural Changes in Systems Engineering"

Leadership
Teaming
Communication
Employee Support
Strategic Thinking
Organizational Climate

- **The Army Transformation**
- **Problems with the Army RAM Engineering Paradigm**
- **Logistics Transformation Task Force (LTTF)**
- **Army Transformation Reliability Improvement Program, ATRIP**
- **Deploying ATRIP, Achieving a Cultural Change in Systems Engineering.**

The Army Transformation Vision

Strategic Dominance	Across Full Spectrum of Operations
Responsive	With Sustained Momentum
Deployable	Brigade Combat Team in 96 Hours, Full Division in 120 hours after Liftoff
Agile	From Support Operations to Warfighting and Back
Versatile	Design Forces That Dominate at any Point on the Spectrum of Operations
Lethal	Provide Lethality & Mobility for Decisive Outcome
Survivable	Develop Technology That Provides Maximum Protection and Leverages the Best Combination of Technologies
Sustainable	Aggressively Reduce our Logistics Footprint and Replenishment Demand



Bottom Line: Transition the Entire Army Into a Force That is Strategically Responsive and Dominant at Every Point in the Spectrum of Operations

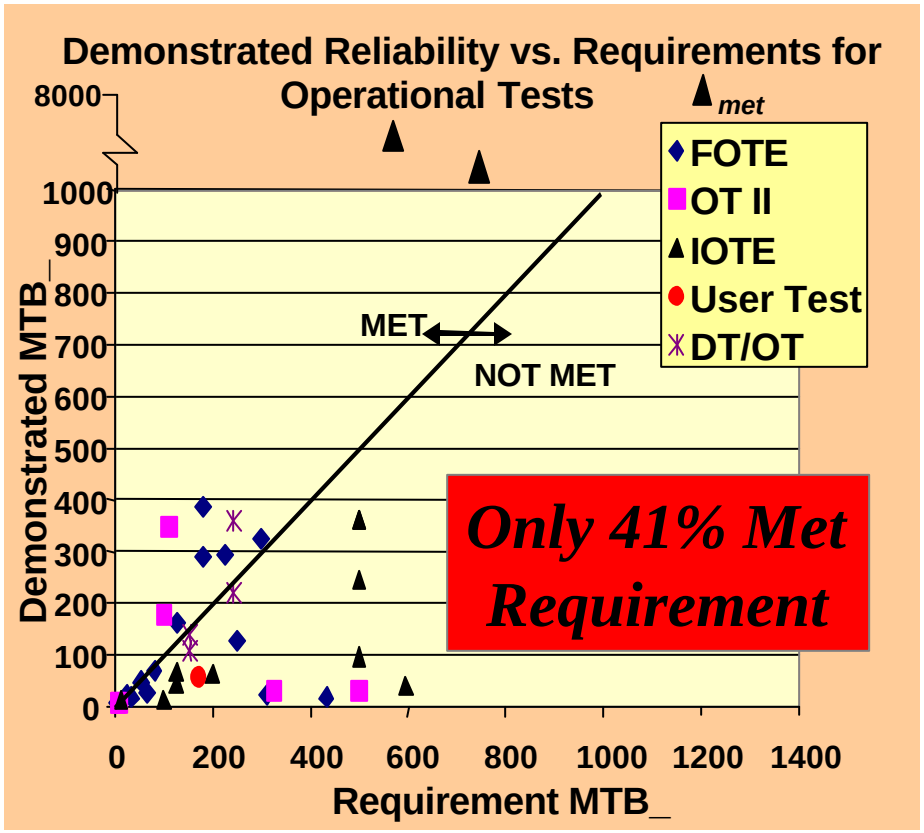
Transformation: Basic Concepts

- Become lightning fast with incredible overmatching combat power across the total spectrum of operations
- Significantly reduce the Logistical Tail, especially manpower dependency
- Significantly reduce the life cycle costs
- Total network centricity. See all and communicate to all levels of operations
- Profound improvements in RMS
  - ZERO combat pulse failures
  - Significant changes maintainability
    - Reduced manpower → << Logistic & Support cost
    - "Pit Stop" concept – Extremely low MTTR → Very Few tools

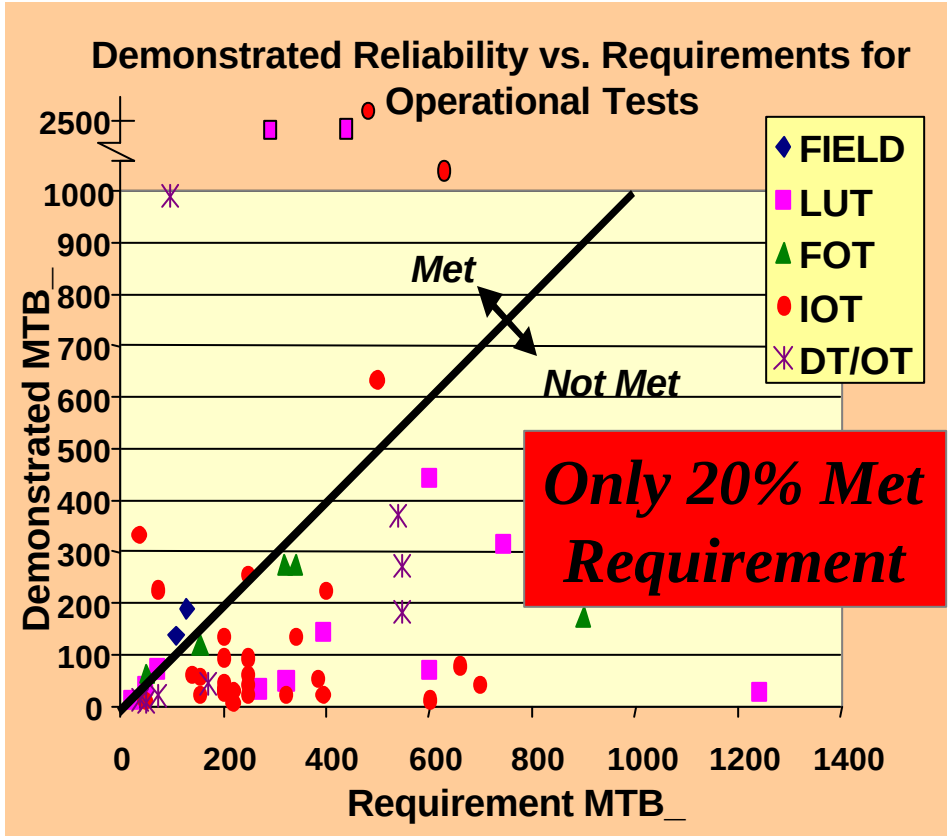
Problems with the RAM Engineering Paradigm

Our Reliability Track Record Is Not Good

1985-1995



1996-2000



Most Of Our Systems Fail To Achieve Reliability Requirements In OT

And The Trend Appears To Be Downwards

source: ATEC/AEC

Our Current 'Reliable' Systems Are Not Reliable Enough

FCS – Where we need to be:

" A deployed FCS force must be capable of operating, at a medium to high optempo, for at least one week without maintaining, rearming or resupply." **(Draft MNS)**

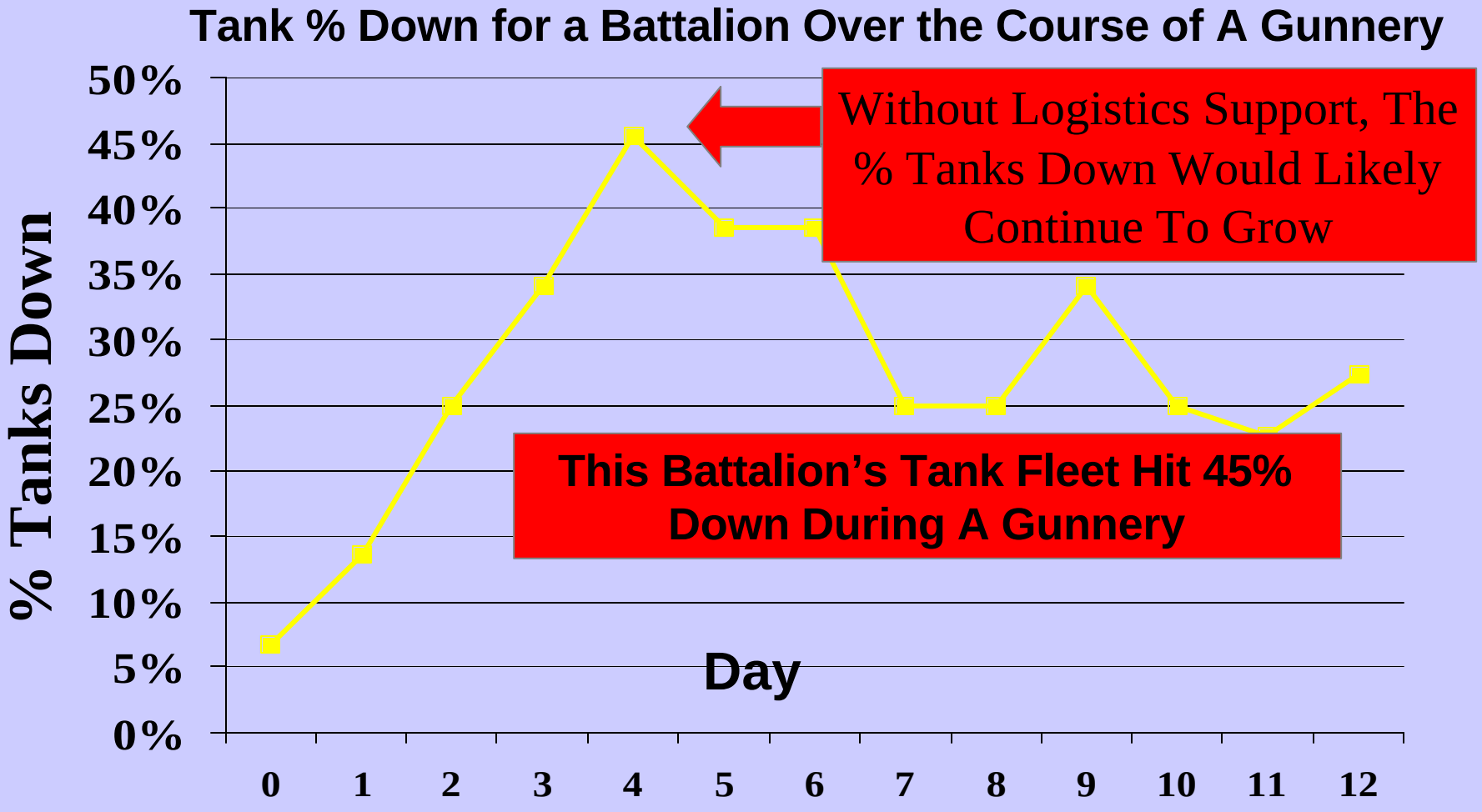
Where we are:

- 46% of M1A1's have a mission critical failure in 3 days during a week of medium to high OPTEMPO at NTC
- 40% for M2's during 7 day combat pulse.

Army Reliability Practices Need To Change
If We Are To Achieve Goals Like That Of The FCS

source: AMSAA

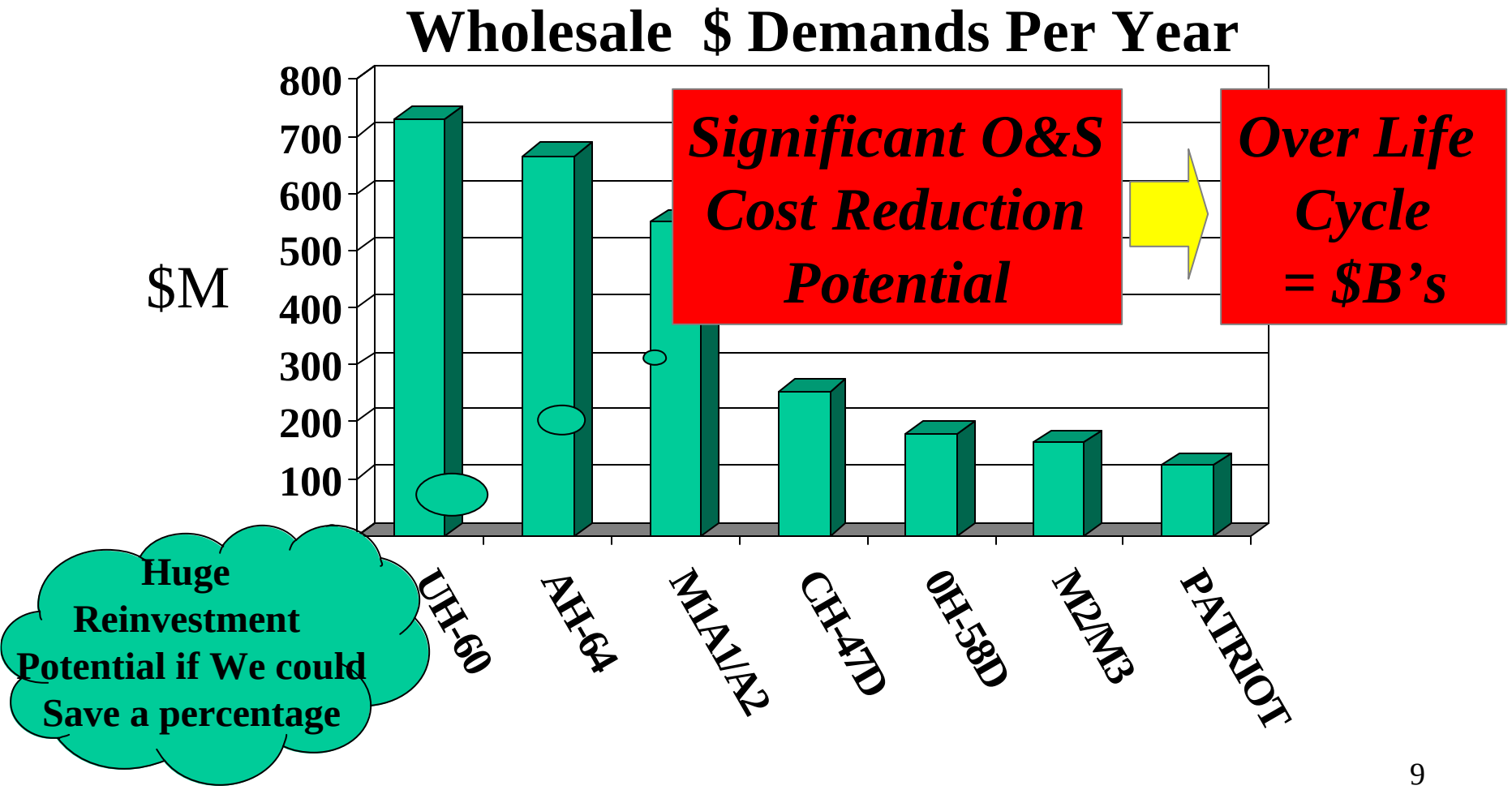
Better Reliability Is Needed To Reduce Log Footprint



With Performance Like This, Systems Require A Large Logistics Footprint

source: RAND

And The Cost To Support Our Current Reliability Levels Is Large



source: JUNE 00 STRAT

Reliability Problems with Munitions Too!
LC Design, Process & Sustainment Issues

General Issues

- **Stockpile is Aging rapidly. Average age close to 20 years. Many different failure mechanisms of concern.**
- **Unique operations and storage configurations causing accelerated degradation:**
  - **Prepositioning Storage on ship and on land**
  - **Uploaded Ammo in weapons**
- **Industrial Base significantly reduced over the past 15 years**
  - **Lost the art & science of manufacturing – LOT Rejections very high**
  - **Surge & Replenishment are questionable**
  - **Single source for many critical components**
  - **Mantech investments only by Congressional plus-ups**
- **Training consuming 85 to 95% of Ammo budget – Very Little Modernization,**
- **Surveillance grossly under-funded – NO Predictive capability - Readiness is a serious question.**

Specific Problems

- **Battery and Electronics failures**
- **Corrosion**
- **Combustible cases – swelling, separation**
- **HE Melt-pour problems – Artillery & Mortar**
- **Mixed Propellant grains – cause accelerated degradation**
- **Propellant bag deterioration – Incompatibility of clothe & propellant degradation products**
- **High submunition hazardous dud rates**
- **Human Factors related Failures - Ineffective Training – Copperhead**
- **COTS**

Army Reliability Problems

Bottom-line:

We do not adequately apply early "Designed-in RAM-Supportability" strategies (using Physics of Failure approaches) to weed out problems with Bad Components, Design, Process, Aging, Human Factors, Operational & Storage Environments, etc… All Causes or Drivers of Safety, Reliability & Availability problems. Also do not carry through on a life cycle RMS focus. "Requires a Paradigm Change" as a minimum

……more likely a Major Cultural Change required…

“True System, and System of Systems Reliability”

- True System Reliability must consider the total system, in all its environments, and all entities that influence outcomes.
- Is there a Problem?
  - An obvious void between Hardware and Software worlds. RAM is a function of both as a “True System”.
  - Other Entities that cause outcomes of Unreliability that must be considered.
    - The Human Entity and the potential for Human Error.
- ***Solution:*** Devise a strategy to bring all entities under a common framework of design, analysis, measurement, assessment, corrective action and continuous improvement.

Human Reliability
or
System Reliability as a Result of Human Error Potential

- GAO Report:
  - Human error caused 20 to 40% of the unreliability of 9 missiles systems studied.
  - Human Error caused 63% of all ship collisions, floodings and groundings
  - Report Conclusion: Human error accounts for approx. 50% of major system failures.
- Operator error typically used as explanation for incidents; yet the true root cause goes much deeper into areas that could be corrected.
- The question then becomes: ***"Did the user commit the root cause, or those who designed the hardware or software fail to recognize something important?"***

RAM Engineering Paradigm

- **We accept failure** because we know we have what it takes to fix things.
- **Lost the Understanding** of the relationship of RAM Engineering with: Logistics, LC Cost, T&E, M&S
- RAM Eng'g **Lost as a "Design Essential LC Process"**
  - **Became an optional "ility"**
  - **Disassociated RAM and Design Engineering disciplines.**
  - **RAM benefits ignored rather than influencing design decisions**
- **Not applying the Basic or Advanced tools, methods and techniques**
- **Loss of focus** on eliminating mechanisms of Failure. Must pursue Predictive Engineering and Physics of Failure
- **Replaced Proactive RAM Engineering** approaches with Test for Success Strategies
- **Acquisition Reform: Eliminated Standards and Guides**
  - Difficulty with contracting for RAM/RMS
- **Incomplete Systems Engineering** due to **deficient RAM Design processes**.
  - Tools deficient and ignorant of state of the art
  - Broken Systems Approach - Human Entity, Both HW and SW, etc…
  - Influence of Aging, Degradation and Process Vulnerabilities ignored

Formulating the ATRIP Strategy

Army Transformation Reliability Improvement Program

Objectives:

- **Correct the Army's Systemic Reliability Problems**
- **Create and Implement A New Paradigm for RAM LC Assurance**
- **Reform the application of the RAM Engineering Discipline and Continuously Improve the Standard of Practice.**
  - **thru practitioning, and liaison create a National Cultural Change**
- **Assure Transformation RMS Success**

"Defining the Problems & Issues with Reliability & RAM Engineering"

Initial Data Sources – 3 year effort

- Workshops on Reliability and Ultra-Reliability.
- AMSAA Reliability Studies for the Army Acquisition Executive
- ATEC/DTC Studies
- CASCOM/DA Studies by RAND Corp.
- PEO/PM Acquisition Program Results
- Operational Support Command – Readiness Assessments
- Six Sigma Program @ PEO-GCS, PEO-Ammo & TACOM-ARDEC
- ATRIP ……etc……..

Workshops & Reliability Studies – Findings

- ***Areas which require corrective actions:***
  - **Policy & Practices**
  - **Reliability Tools**
  - **T&E and M&S**
  - **Training**
  - **Supportability**
  - **Systems Engineering**
    - **RAM Design vs "ility"**
  - **Program Management**
  - **Field Data Feedback**
  - **Data Management**
  - **Contracting for Reliability**
  - **Etc…….**

Primary Focus on <u>Defining</u> little emphasis on <u>Measure, Analyses</u> <u>Improvement</u> and <u>Control</u>

Six Sigma DMAIC

"Need for Army Integration Lead"

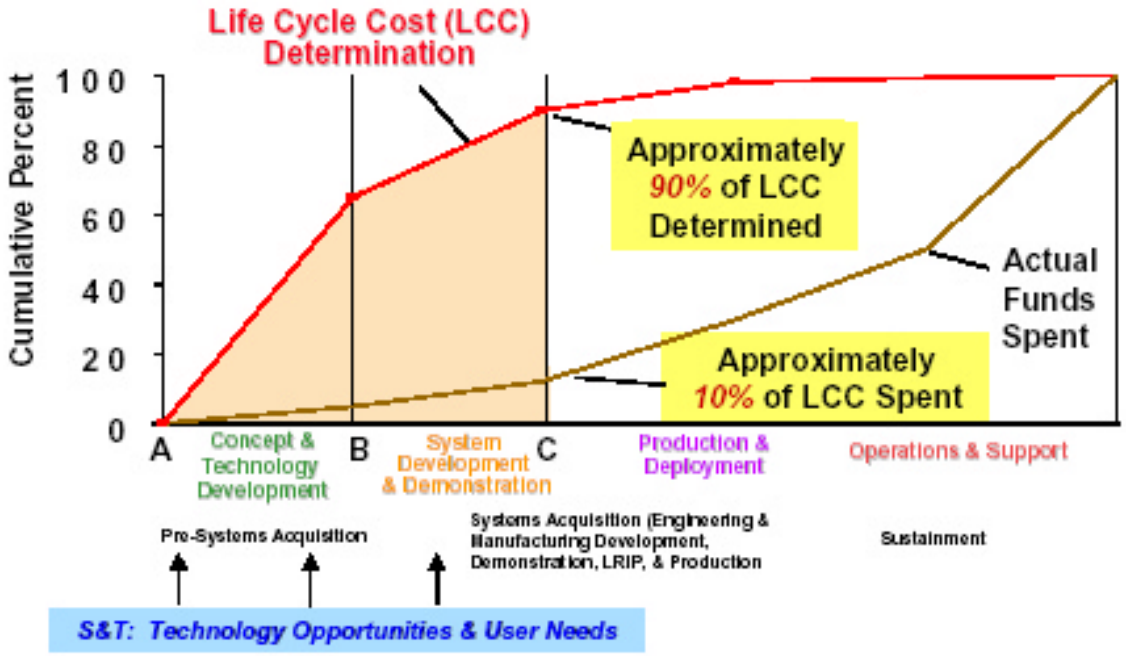
The Current Paradigm – We accept Failure because we know we can Fix things
Hence the enormous Logistical Tail
Standard of Practice – Treated as an "ility", Not a Design essential process

Some “Initial”Proposed Solutions
For Improved RMS

- Redundancy
- Focused testing
- Designed-In Ultra-Reliability - Inherent reliability
- Diagnostics and Prognostics
- Design Modularity – On-board Spares
- Commonality – Common Chassis, Common Components
- Reduced Weight equals reduced failures and reduced logistics
- Better Trained Logistical Supportability
- Contracting for reliability

No Single Silver Bullet
Requires a combination of strategies and More

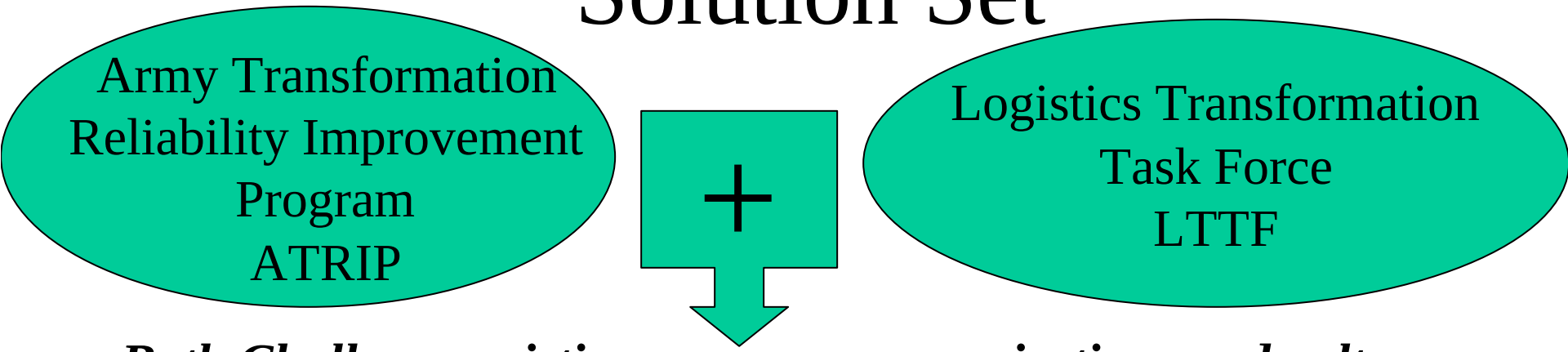
Requires a Cultural Change



Logistics Transformation Task Force

- To be successful, new logistics concepts will require significant RMS enhancements to the designs of our systems.
- "Early stages of the program are when the greatest benefit from RMS decision process improvements can be realized."
- "Although constrained acquisition budgets will continue to make the Army's Transformation challenging, the affordability of RMS improvements will have to be viewed in the context of entire life cycle costs. A corporate Army perspective may trade procurement quantities for RMS enhancements if the result is a lower net present value over the system life and greater availability of that system in combat.

Solution Set



Both Challenge existing processes, organizations and culture

<u>Change the paradigms and standards of practice that deter success</u>

- ✓ RAM upfront and early – not traded away, not a separate "ility", but a design optimization process that drives "decisions"
- ✓ State-of-the-art RAM, Physics-based and M&S Tools and methods make optimization of Cost, Performance, Schedule and Supportability routine, not just possible.
- ✓ Understanding RAM, Supportability and LC Cost relationships leads to Systems Approach with a much needed "Cost Reduction Culture", which in turn pays for Transformation improvements.
- ✓ Cultural Change is the only way.

Solution Set - Strategy

- **Eliminate old paradigm and create a new Std of Practice for RAM Eng.**
  - **Based on Transformation Operational Objectives**
  - **Visibility of RAM Engineering in Design & Process Decision Mgt.**
- **Aggressive Core Competency Enhancement Program**
  - **Knowledge, Skills, Abilities**
  - **Advanced State of the Art Tools, Methods**
  - **AMC, Industry, Academia, Professional Societies**
- **Establish Change Management Processes:**
  - **Champions, Change Agents, Oversight, Independent Peer Review**
- **Focus our Change Management processes on "Right" Target Audiences:**
  - **Senior Army Acquisition Leadership, PEO/PM Community, Army Materiel Command - MSC's, RDEC's, T&E, TRADOC etc…**
  - **Industrial Base – Prime Systems Contractors, Suppliers, Vendors, Organic Production Base**
  - **Academia, Professional Societies**
- **Apply Discipline at all levels to assure success**
  - **Project Level - Apply "Design for 6 Sigma" and "Lean" tools & philosophies**
  - **Organization Levels - Capability Maturity Model-type Assessment & Continuous Improvement**
- **Create Implementation Structure & Program**
  - **Distributed Centers of Excellence, RMS Clearinghouse, Assessment & Deployment teams, Aggressive Industry Liaison Team, AMC Quality Federation**

And Complete Broad-based attack

Some Major Areas of Focus

"Must be Built into the Systems Engineering Process"

- Disciplines of Six Sigma, Lean and CMMI
- Predictive Engineering & Physics of Failure
  - Predictive Models & Algorithms
  - RAM Tools
- Diagnostics & Prognostics
- IIT – Information Integration Technology
- Probabilistic Technology
- Contracting for RAM
  - Business Cases methods
  - Incentives
- Organizational Core Competency Assessment mechanism
- RMS Innovations
  - Technology
  - Engineering
- Core Competency Growth & Deployment Mechanisms
- RAM/RMS Culture Change – New Std of Practice

ATRIP -Framework

Develop, Deploy and Continuously Improve upon a new RAM Culture

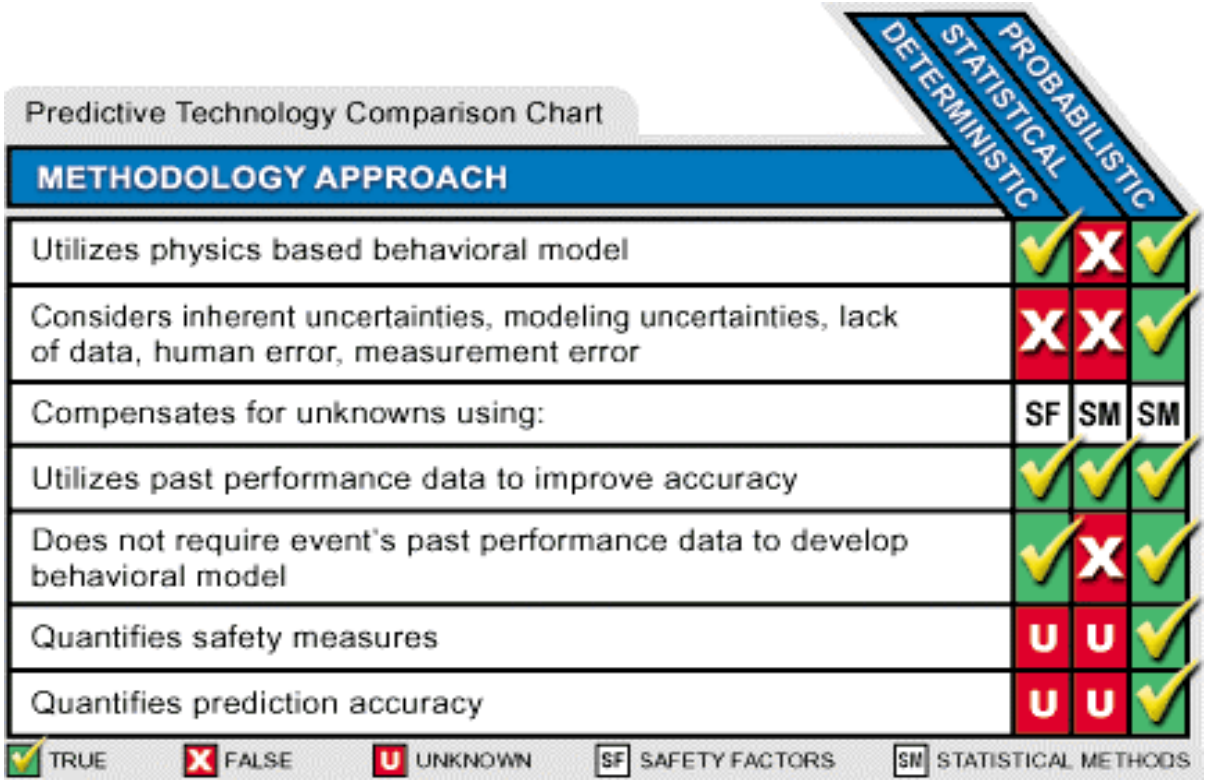
- **Clearing house for RMS Innovations**
  - **Engineering & Technology Solutions**
  - **State-of-the-Art Toolkit, M&S tools, Methods, Best Practices, Process Mgt**
  - **Contracting –Business Case and Incentives**
  - **Maintain data base & Deploy latest RMS innovations**
  - **Knowledge Base for Core Competency Enhancement Program**
- **Assessment Team – Capability, Performance, LC Cost, Tradeoffs/CBA/ROI**
  - **Continuous Process Improvement**
  - **RMS Risk Management - Government/Industry process, methods, etc.**
- **Deployment Team**
  - **RAM Design and assessment from tech base to Demil**
  - **Direct support to IPTs, TSMs, PMs**
  - **Teaming with Contractors**
  - **Core Competencies, Business and Technical processes, etc.**
- **Industry Liaison Team – A National Cultural Change**
  - **Professional Societies; Industry Practitioners**
  - **Mature the RAM Core Competencies across the National Industrial Base**
  - **Tools & Methods development and Success Stories**

Solution Set -"Technical"

- ***Basic Tools*** **-**
  - **Reliability Program Plans, Functional & Math Models, Block Diagrams,**
  - **FOCUS on Physics of Failure and Predictive Engineering.**
  - **FMECA, FTA, Reliability Growth**
  - **Advanced Data Analysis Techniques**
  - **LC Environmental Analyses (MILSTD 810F)**
- ***Advanced Tools & Methods–***
  - **Bayesian Methods tied to Growth Planning & Prediction (PREDICT)**
  - **Accelerated Life & Accelerated Aging Methods: DOE, Predictive Models**
  - **Robust Design - DOE, Taguchi**
  - ***Probabilistic Methods - Greater emphasis on failure definition and exclusion***
  - **Aging and Durability Analyses….Life Cycle Prediction**
  - **Algorithm Development for Diagnostics and Prognostics**
  - **Advanced Surveillance and Field Data Feedback Practices – Laboratory Testing, Advanced Telemetry applications, diagnostic/prognostic applications, etc….**
  - **Advanced Contracting Methods – Business Case & Incentives**
  - **Reliability Test Designing – Optimization of Data and Cost to conduct T&E**
- ***New Tool Development –***
  - **Diagnostic & Prognostic Sensors Integrated with Aging/Durability Algorithms**
  - **Systems of Systems Models**
  - **Improved Contractual Incentives for Reliability and Business Case maturity**
  - **Advanced NDE with MEMS**
  - **Probabilistic Design Tools – integrated with physics-based models and LC Cost M&S**

Probabilistic Technologies

- **Probabilistic technology incorporates the best of Deterministic and Statistical approaches.**
- **Models outcomes using physics-based models, using all variables as random, applies uncertainties for model imperfections, measurement and human errors, etc…**
- **Provides the Most Probable outcomes, computes probabilities of all desired events, discerns drivers or root cause mechanisms etc…**
- **Maximize and Optimize all designs and processes for all inputs and outcomes.**



Why PoF & Predictive Engineering?

PREMATURE STOCKPILE DETERIORATION

AS A RESULT OF

DESIGN & PRODUCTION DEFICIENCIES

&

TRANSPORTATION & STORAGE CONDITIONS

A FUNCTION OF:

not understanding the "real" environments

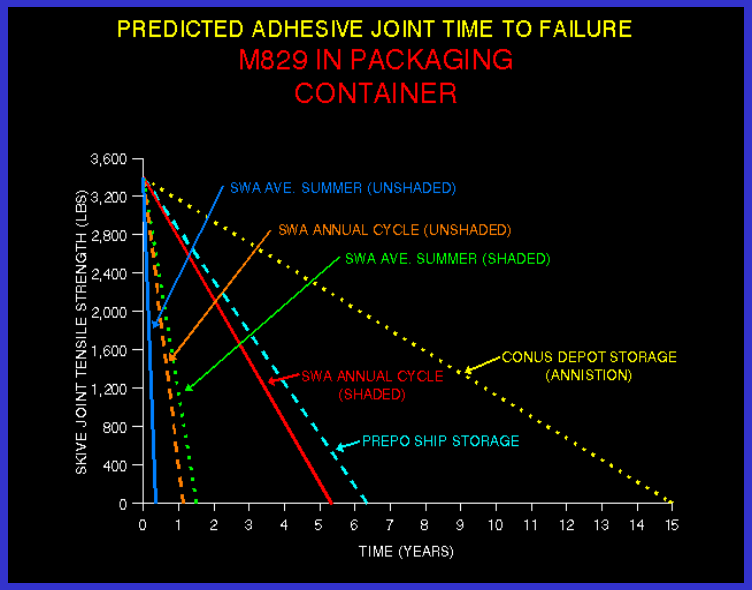
&

not using adequate life cycle tools to assure and assess materiel robustness against premature failure/deterioration

Life Cycle Analysis

Model Applications

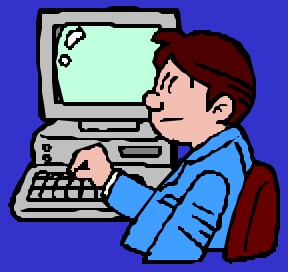
Physics of Failure Life Limiting Components



Predictive Algorithms

Improve the Design

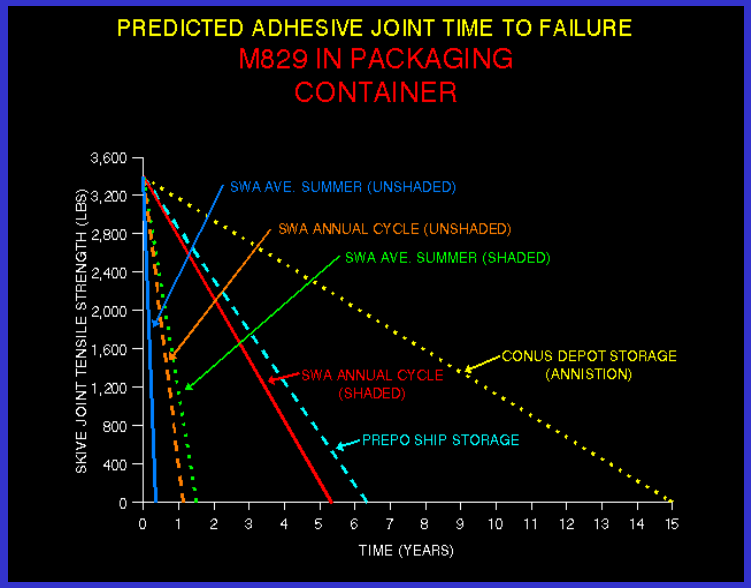
Control Processes

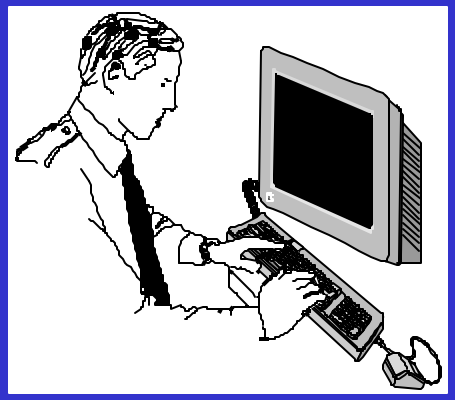


Optimize Stockpile Management

- **Sustainment**
- **Readiness**

Life Cycle Analysis - Sustainment



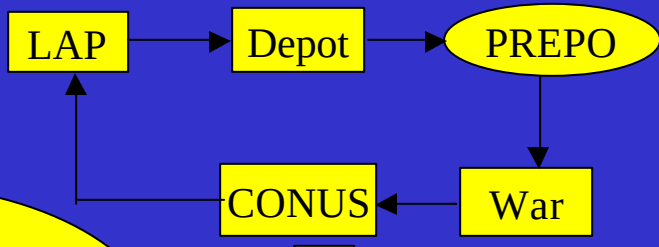


Life Cycle Simulation

ITEM Manager PEO/PM/SMCA

- **Surveillance Frequency**
- **Maintenance**
- **Condition Code**
- **Priority Usage**
- **Prepositioning**
- **Foreign Military Sales**
- **Demil**
- **Obsolescence**

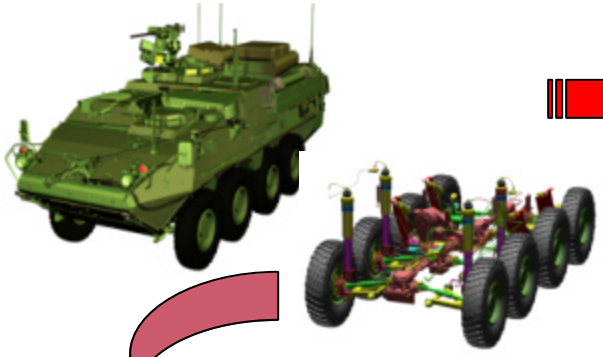
- **Total LC Log Process**
- **Total Ownership Costs**
- **Cost As an Independent Variable (CAIV)**



Science & Physics-based Decision Morphology

Integration of RAM Tools with Design, M&S and T&E

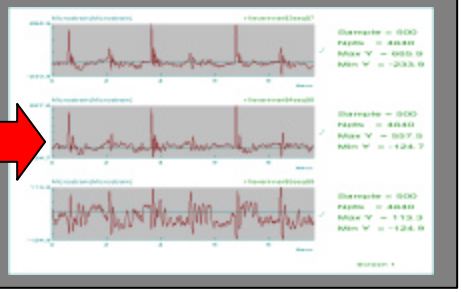
CAD



Test & Evaluation

Automotive Durability

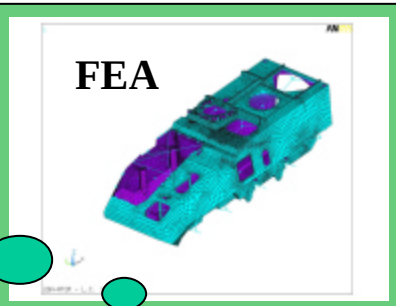
Strain Time History

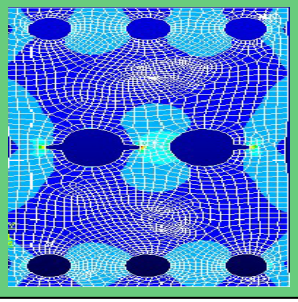


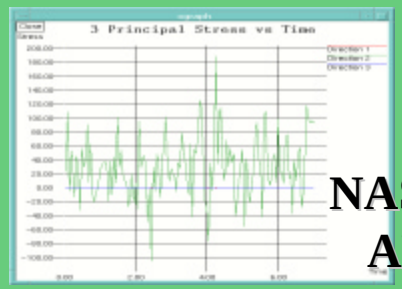
Component Stress Analysis

Empower With Probabilistic Tools

FEA





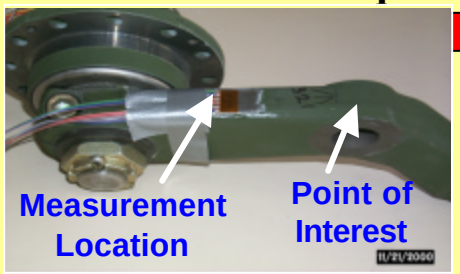


NASTRAN ANSYS

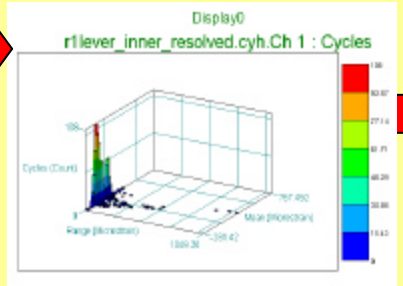
Component Durability Analysis

nCode

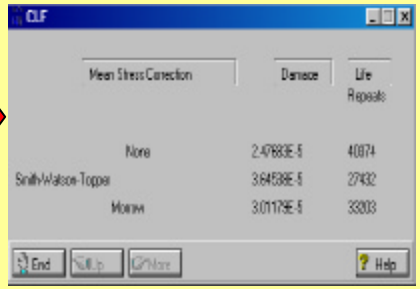
Stress Correlation - FEA or Classical Techniques



Rainflow Analysis



Service Life Prediction



Source: AMSAA/D. Mortin, PhD.

Organizational RAM Core Competency Assessment Mechanism

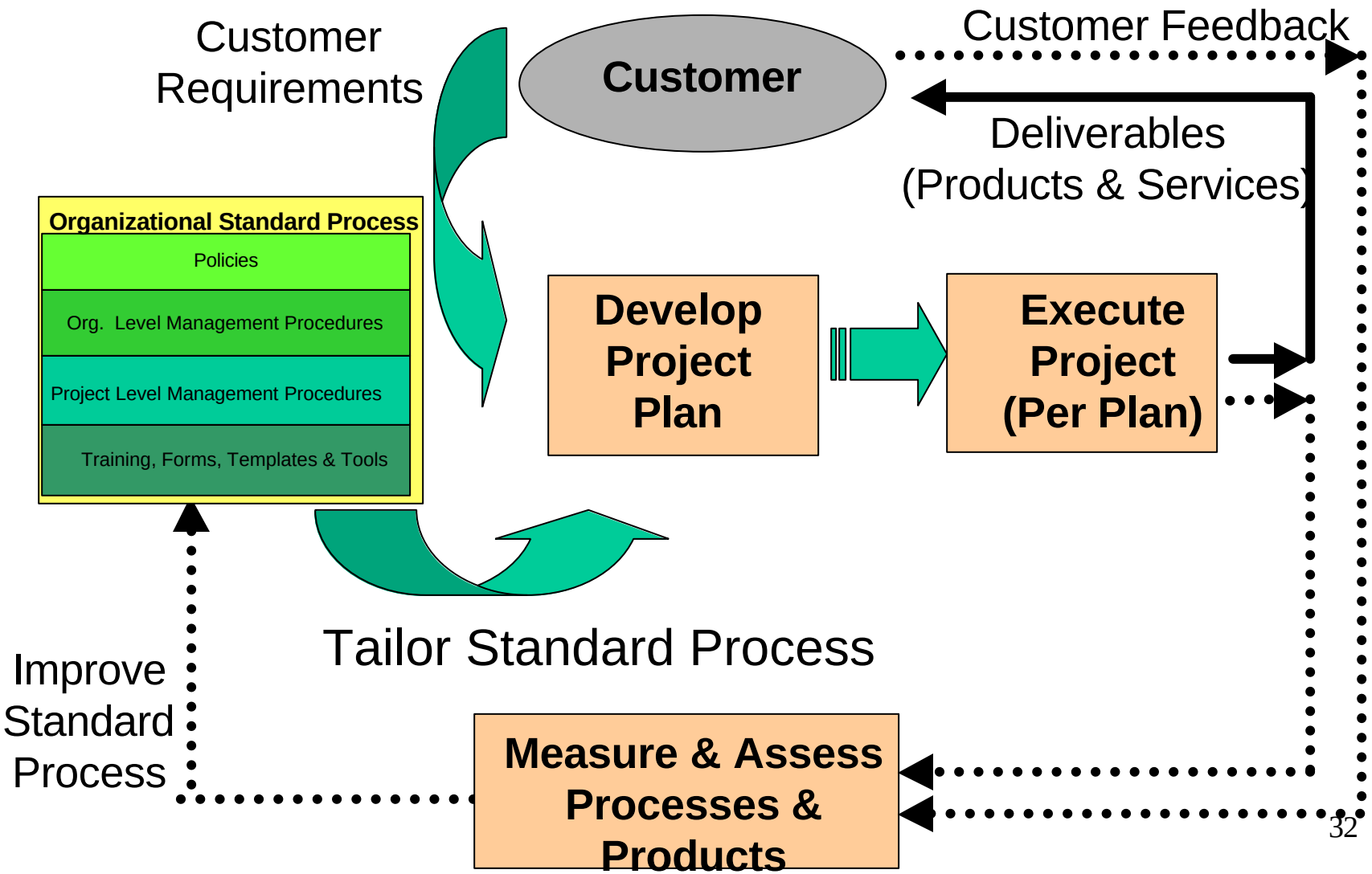
- CMMI-like Mechanism: System Model for Enterprise Process Improvement
- FOCUS on Processes that create RAM products & services
- Use Results as Indicators of Process performance

- 5 Levels of Assessment:
  - Level 5 – Optimizing
  - Level 4 – Quantitatively Managed
  - Level 3 – Defined
  - Level 2 – Managed
  - Level 1 – Initial

- Used to Build and Deploy the New RAM Paradigm and to Assure Continuous Improvement of Core Competencies and associated business practices and internal control mechanisms.

Typical CMMI Implementation

ATRIP Fits the Same Model for RAM/RMS



ATRIP Teaming Concepts

- **Teams built on partnerships to coordinate, develop, implement and execute a total Army program.**
  - **Includes:AMSAA,RDE Centers, MSCs, FCS-LSI, LIA, TRADOC, ASAALT, PEO/PMs, AMC… etc…**
  - **Address Technical, Program Management, Policy, Systems Engineering, Contracting etc..**
  - **Dynamic team environment**
    - **Lead & Linked by an Essential Core Change Agent**
    - **Numerous teams staff up, execute and disband as required from a pool of experts (Govt, Industry, Academia, etc).**
    - **RMS Clearinghouse is permanent team.**
  - **All Army Programs should benefit**
- **Government & Industry shared Mission & Vision**

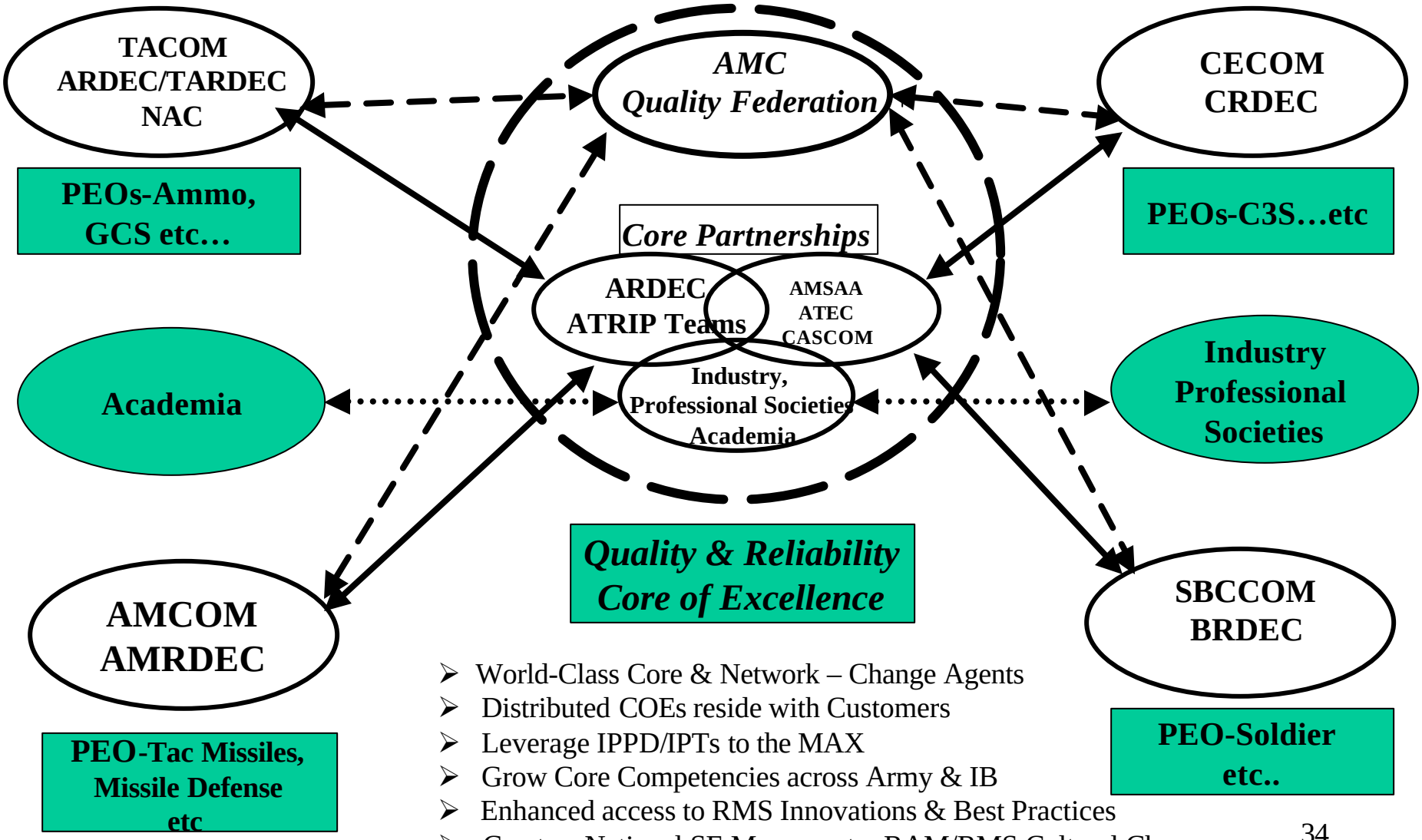
ATRIP Structure

- ***RMS Clearinghouse***
- ***Assessment Team***
- ***Deployment Team***
- ***Industry Liaison Team***

<u>Conduit for Success</u>

- ***AMC Quality Federation***
- ***IPT Systems Engineering Processes***
- ***Distributed Centers of Excellence***

Distributed Centers of Excellence



- World-Class Core & Network – Change Agents
- Distributed COEs reside with Customers
- Leverage IPPD/IPTs to the MAX
- Grow Core Competencies across Army & IB
- Enhanced access to RMS Innovations & Best Practices
- Create a National SE Movement – RAM/RMS Cultural Change

Near Term - Action Plan

- Briefing to Army Acquisition Executive and Commanding General, AMC for joint approval to implement on all Army programs, NLT 15 Nov 02
- Initiate Industry Liaison Team/Committee processes:
  - **ID Professional Societies, Industry Leaders in RAM/RMS etc**
  - **Initiate Workshop #1 development process NLT 1Nov 02**
  - **Conduct Workshop #1 NLT 30 Jan 03**
  - **Plan Initial Conference and other mechanisms to leverage RMS Innovations**
- Begin Core Competency growth process across all Army and Industrial Base partners
  - **Deploy basics through the AMC Quality Federation, AQF**
    - **Use Industry Liaison Team to reach Industry & Academia**
  - **Assess levels of maturity, design continuous improvement plans**
  - **Implement Best Practices and provide Toolkits to all IPTs**
  - **Facilitate as required**
- Begin Serious Implementation on All Programs

Summary

- **Without significant changes, Objective Force equipment will likely experience the same level of low reliability with the consequences of high labor-intense logistics and high LC Cost as with current weapon systems.**
- **Reliability must be designed in upfront**
  - **The tools and technology exist; emerging tools need to be resourced**
  - **“Standards of Practice” must be revamped with cultural changes for success.**
  - **High reliability does not need to come with a high price tag.**
- **Need a strong Team effort, Champions, and Change Agents – Distributed COEs**
- **Contracting for reliability is key.**
- **RMS KPPs are essential, Incentives a Must, Business Case analyses must drive all RMS improvements.**
- **Discipline in the form of 6 Sigma, Lean and Capability Maturity Model (CMM) type approaches being used for program and organizational success assurance.**
- **ATRIP provides the organization, technical & business tools, processes, best practices and continuous improvement framework to accomplish this Cultural Change**
- **Implementation initiated on the Future Combat System**
- **Final Approval and resources anticipated in Nov 02 – Launch Organizational framework and begin broad-based program attack.**
- **Must Start up Industry Liaison process NOW – Plan Workshop to focus efforts**